

THE MOVING GARDENS: REEF FISHES GRAZING, CLEANING, AND FOLLOWING GREEN TURTLES IN SW ATLANTIC

by

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ABSTRACT. - Reef fishes may associate with marine turtles and graze on their shells, or clean their head, neck and flippers. On a reef flat at Fernando de Noronha Archipelago, SW Atlantic, we recorded green turtles (*Chelonia mydas*) grazed, cleaned and followed by reef fishes. The green turtle seeks specific sites on the reef and pose there for the grazers and/or cleaners. Fishes recorded associated to green turtles included omnivorous and herbivorous reef species such as the damselfish *Abudefduf saxatilis* and the surgeonfishes *Acanthurus chirurgus* and *A. coeruleus*. The turtle is followed by the wrasse *Thalassoma noronhanum* only while engaged in foraging bouts on benthic algae. Following behaviour is a previously unrecorded feeding association between turtles and fishes.

RÉSUMÉ. - Des jardins mobiles: des poissons de récif broutent, nettoient et suivent les tortues vertes dans l'Atlantique occidentale.

Des poissons de récif peuvent être associés à des tortues marines; ils broutent les algues poussant sur leurs carapaces cornées ou nettoient leur tête, cou et pattes. Sur un platier récifal de l'Archipel de Fernando de Noronha, Atlantique occidentale, des tortues vertes (*Chelonia mydas*) broutées, nettoyées et suivies par des poissons de récif ont été observées. La tortue verte cherche des sites spécifiques dans les récifs, où elle se repose pour que les poissons viennent brouter sur leur carapace et/ou les nettoyer. Les poissons associés à la tortue verte sont des espèces récifales omnivores, comme le poisson demoiselle *Abudefduf saxatilis*, ou herbivores comme les poissons chirurgiens *Acanthurus chirurgus* et *A. coeruleus*. La tortue est suivie par le labre *Thalassoma noronhanum* seulement pendant qu'il se nourrit d'algues benthiques. L'association entre tortues et poissons suiveurs est observée pour la première fois dans l'Atlantique occidentale.

Key words. - Acanthuridae - Pomacentridae - Labridae - *Chelonia mydas* - ASW - Fish foraging - Symbiosis.

Marine herbivorous fishes may graze upon algal growth on turtles' shell, getting food and thus reducing drag for the turtle (Losey *et al.*, 1994). Three species of surgeonfishes, *Acanthurus nigrifuscus*, *Ctenochaetus strigosus* and *Zebrasoma flavescens* are reported to graze on the green turtle, *Chelonia mydas*, in Hawaii (Losey *et al.*, 1994). They graze largely on the shell, but occasionally may feed on skin areas, and in both instances the surgeonfishes scrape the algae in their typical feeding pattern of tightly clustered bites (Losey *et al.*, 1994). Herbivorous fishes that graze on turtles' shells and other body areas may consume molting skin from the head and neck, and apparently may remove ectoparasites as well, thus occasionally acting as cleaners (Losey *et al.*, 1994).

Cleaning symbiosis is another kind of feeding association recorded between fishes and turtles (Booth and Peters, 1972; Losey *et al.*, 1994). In this association the cleaners feed on ectoparasites, diseased or injured tissues, and mucus from the body surface of their "clients" (generally other fishes), which in their turn get rid of unwanted material (review in Losey, 1987). Several cleaner species hold clean-

ing stations, specific sites on the reef visited by clients seeking for cleaning services (Losey, 1978). Cleaning symbiosis in coral reefs involves fishes and shrimps as cleaners, and fishes as well as reptiles as clients (Feder, 1966; Hobson, 1969; Booth and Peters, 1972). Cleaning association with the turtle *Chelonia mydas* is reported for four reef fish species, the damselfish *Abudefduf sexfasciatus* and the wrasse *Thalassoma lunare* in Australia (Booth and Peters, 1972), as well as the wrasse *Thalassoma duperrey* and the puffer *Canthigaster jactator* in Hawaii (Losey *et al.*, 1994). For marine turtles other than *C. mydas*, cleaning association is reported for the hawksbill *Eretmochelys imbricata* and the angelfish *Pomacanthus paru* in the Caribbean (Smith, 1988).

Following behaviour is an unrecorded feeding association between fishes and turtles, although a common habit among several reef fishes (e.g., Hobson, 1968; Diamant and Shpigel, 1985; Strand, 1988). Such feeding association implies in a "nuclear" species which disturbs the substrate during its foraging and thus displaces or uncovers hidden prey, and "follower" species which capitalize on this other-

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wise unavailable food supply (Hobson, 1968, 1974; Diamant and Shpigel, 1985; Strand, 1988). Several reef fish species have been recorded associated with octopuses, moray eels, rays, and other substrate-disturbing fishes (Karplus, 1978; Ormond, 1980; Diamant and Shpigel, 1985; Strand, 1988).

Herein we report on reef fishes grazing on, and cleaning, the green turtle (*Chelonia mydas*) on a reef flat at Fernando de Noronha Archipelago, SW Atlantic. Additionally, we record a wrasse species following the turtle while the latter is engaged in foraging bouts on benthic algae. Besides general observations on the cleaning association between green turtles and their cleaners and followers, our study addressed the following questions: Does the grazing/cleaning association take place at any site of the reef flat or do the green turtles seek the cleaners at their stations? During inspecting and/or cleaning the turtle, do the cleaners concentrate on any specific body part? How do green turtles behave while being grazed/cleaned? What a planktivorous and cleaning wrasse (Francini-Filho *et al.*, 2000) seeks while following a turtle?

MATERIAL AND METHODS

Our field observations were conducted at a reef flat of the Baía do Sueste, Fernando de Noronha National Marine Park, Fernando de Noronha Archipelago (03°50'S, 32°15'W), off NE Brazil (see Maida and Ferreira, 1997; Carleton and Olson, 1999 for maps and description). The interactions between turtles and fishes were first documented in February 1999 and then sporadically recorded from October 2001 to October 2002.

The study site is within an inlet and is composed by an inner, protected reef flat and shallow area near shore and an outer reef slope leading to deeper parts of the Baía do Sueste (Fig. 1). The flat and the slope are built by sandy bottom and irregular rocky patches sparsely to thickly covered by brown foliose algae, red coralline algae, and stony corals (Maida *et al.*, 1995; Sanches and Bellini, 1999).

The behavioural events involving reef fishes and green turtles were recorded over 56 days while snorkelling. During the observational sessions of 1-12 min we used 'focal animal' sampling, in which all occurrences of specified actions were recorded (Altmann, 1974). Beside records pencilled on plastic slates, behavioural events were photographed and video-recorded, the tape being on file at the Museu de História Natural, Universidade Estadual de Campinas (ZUEC tape # 14) and at the Tamar/Ibama quarters in the National Marine Park of Fernando de Noronha Archipelago.

The analysed video-recorded sequence, with the turtle posing and the fishes inspecting and feeding, lasted for about 11 min. We considered fishes facing the turtle and positioned less than 15 cm away from its body as inspecting

it, and scored a feeding nip only when it was unmistakably recognized as such. For precision sake we used only the video-taped sequence in which feeding nips could be unmistakably counted (about 4 min). Hence, our inspection/feed counts presumably underestimate the number of feeding nips, especially those on the turtle's shell due to its disruptive pattern and the thus sometimes blurred effect.

Due to the protected status of the study site we refrained from sampling grazer/cleaner individuals for gut contents, as this would imply spear-fishing and use of this gear would raise strong opposition from both the islanders and the tourists. However, we scraped off material from the shell and soft parts of the turtles (N = 2) to gain insight into what may be available as food to the grazers and cleaners. The material sampled from the turtles, collected exclusively from cleaned individuals, was examined and identified under a stereomicroscope and a microscope. Additionally, we inspected three turtles visually for the presence of larger attached organisms (e.g., barnacles, leeches).

RESULTS

We recorded green turtles foraging on benthic algal banks at high tide in a relatively large area of the reef flat of the Baía do Sueste (Fig. 1) at sites 1-2 m deep. Fishes following the foraging turtles were recorded at these feeding grounds only. On the other hand, grazing/cleaning associations were restricted to the deeper (2.5-4.5 m) parts of the slope (Fig. 1), where we recorded two cleaning stations at the high tide.

The two cleaning stations were held by the ubiquitous damselfish *Abudefduf saxatilis* and the surgeonfishes

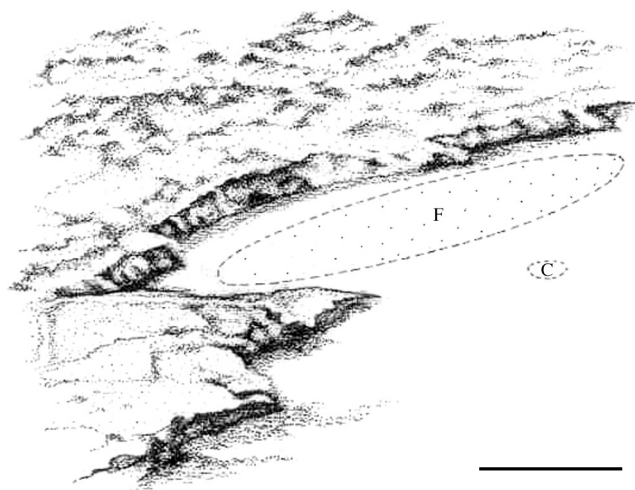


Figure 1. - Green turtle's feeding (F) and cleaning (C) grounds at the Baía do Sueste, Fernando de Noronha Archipelago, SW Atlantic. Scale bar = 50 m.

Table I. - Reef fish species, inspection and feeding nips at body parts of the green turtle (*Chelonia mydas*), as scored from 4 min video-recording at the Baía do Sueste, Fernando de Noronha Archipelago, SW Atlantic.

Fish species	Inspections/feeding nips (n = fishes close to the body part)		
	Shell	Flippers	Head/neck
Pomacentridae			
<i>Abudefduf saxatilis</i>	3/0 (n = 1)	16/3 (n = 1-2)	13/13 (n = 1-2)
Acanthuridae			
<i>Acanthurus chirurgus</i>	16/6 (n = 1-8)	35/14 (n = 1-6)	10/9 (n = 1-3)
<i>Acanthurus coeruleus</i>	2/0 (n = 1)	8/2 (n = 1-2)	1/0 (n = 1)

Acanthurus chirurgus and *A. coeruleus*. The cleaning stations were located at calcareous concretions and rocky outcrops where the cleaners (12-25 individuals about 7-12 cm TL) concentrated and hovered about 0.5-1.5 m above the station and/or the bottom.

The three above-mentioned reef fish species were recorded inspecting the green turtle's shell, but only the doctorfish (*A. chirurgus*) was actually feeding on this body part (Tab. I). The grazing behaviour by surgeonfishes on turtles was recorded only at the cleaning stations, simultaneously to inspection and cleaning of its soft parts by other individuals of the same or other species (Tab. I). The grazing by surgeonfishes on the green turtle's shell followed their usual bite pattern while grazing on bottom algae at the study site (pers. obs.).

Cleaning/grazing on the green turtles' soft parts was recorded for the damselfish and both the two surgeonfish species (Tab. I). This was preceded by a characteristic inspection usually followed by feeding nips on the turtles' skin surface. Some of the bites were forcible and clearly directed to particular, visible items on the turtle's skin. On occasions the turtle moved its forelimbs to chase away fishes that were feeding in this way. The most inspected and cleaned body parts were the flippers (Tab. I). Neck and head areas were also inspected and cleaned, whereas the anal



Figure 2. - A green turtle foraging on benthic algae, followed by four individuals of the wrasse *Thalassoma noronhanum* (close to left side of carapace) on a reef flat at Fernando de Noronha Archipelago, SW Atlantic. Curved carapace length about 54 cm. From a video-record frame by A. Grossman.

region went untouched by the fishes.

Tufts of small filamentous algae dominated the samples scrapped off the turtles. The brown *Ectocarpus* cf. *breviarticulatus* (Ectocarpaceae) and the red *Herposiphonia secunda* (Rhodomelaceae) were present in similar amount in the soft parts (neck, limbs) samples. Other algae were rare on these samples, including the green *Cladophora* sp. (Cladophoraceae) and the red *Jania* cf. *adhaerens* (Corallinaceae). The brown *E.* cf. *breviarticulatus* dominated the shell samples as well, whereas *H. secunda* was scarce there. In the shell samples we also found a plantule of the brown *Dictyota* sp. (Dictyotaceae). We found no parasites or other epizoic animals in our samples. On the visually inspected turtles, besides the aforementioned algae, we found very few turtle barnacles on the shell (see Bugoni *et al.*, 2001 for Brazilian commensal barnacles of sea turtles).

At the cleaning stations the turtles displayed characteristic soliciting postures (cf. Losey *et al.*, 1994). While being grazed and/or cleaned a turtle remained almost motionless with its flippers extended and drooped downward, in a posture more exaggerated than that illustrated by Booth and Peters (1972). Its neck was extended and bent downward throughout most of the cleaning session. While engaged in a cleaning association, the turtle hovered above or by the cleaning station, about 0.5-1.5 m away from the bottom.

We recorded no inspecting by cleaner fishes or cleaning associations while the green turtle was foraging, and recorded no feeding activities by the turtle while it was attended at the cleaning stations. The turtle seemed rather to concentrate on the cleaning, and held its position close to the station using discrete limb movements. We recorded the turtle raising to the surface for breathing, and thereafter actively seeking the same site where it was being cleaned before the surfacing.

At the green turtles' feeding areas (Fig. 1) we recorded another kind of association with reef fishes. While on a foraging bout the turtle selected and picked up benthic algae on the reef flat and was occasionally followed by the wrasse *Thalassoma noronhanum*. One to four fish (6-8 cm TL) were recorded closely following the turtle, and feeding on drifting particles turned loose from the bottom by the turtle's feeding activity. The fish approached the turtle's fore-body mostly when the latter picked up the algae stirring the substrate a little (Fig. 2).

DISCUSSION

Several reef fish species that act as cleaners occupy cleaning stations or areas, either permanent or temporary, mostly located on conspicuous portions of the reefs (Feder, 1966; Losey, 1987; Sazima *et al.*, 1999). The cleaning stations at the Baía do Sueste follow the general pattern found

for other reef species that act as cleaners in mid-water aggregations, e.g., the labrid *Thalassoma noronhanum* and the chaetodontid *Chaetodon striatus* (Francini-Filho *et al.*, 2000; Sazima and Sazima, 2001). The stations held by the damselfish and surgeonfishes were conspicuous within the relatively bare reef flat environment, which rendered the hovering cleaners easy to find by humans (and presumably by the turtles as well).

Surgeonfishes are regarded as an almost entirely herbivorous group and dependent on algae as their primary food (Randall, 1967; Böhlke and Chaplin, 1968; Earle, 1972). The algal-eating acanthurids are able to exploit diverse micro-habitats during their foraging (e.g., Earle, 1972; Hobson, 1974; Losey *et al.*, 1994), and the three species of *Acanthurus* recorded on the Brazil's coast feeds on algae growing on sand surface, attached to rocks, and drifting in the water column (Dias *et al.*, 2001). Even if foraging mostly on algae, *Acanthurus bahianus* and *A. chirurgus* may be regarded as omnivores that supplement their herbivorous diet with detritus, benthic micro-fauna, and plankton as well (Randall, 1967; Duarte and Acero, 1988). Furthermore, searching for other food sources and/or situations may be a common trait for some *Acanthurus* species (Duarte and Acero, 1988; Dias *et al.*, 2001). Thus, algae attached to the shell of marine turtles represent another grazing opportunity for those species able to notice and exploit this food source. Moreover, besides the algae on the shell the opportunistic acanthurids may take molting skin and perhaps ectoparasites as well, both items found on the turtles' soft parts (Booth and Peters, 1972; Losey *et al.*, 1994). Thus, the feeding association of acanthurids with marine turtles is likely related to their ability to exploit diverse micro-habitats while foraging plus their flexible diets, even if mostly based on algae (Randall, 1967; Duarte and Acero, 1988; Dias *et al.*, 2001; Losey *et al.*, 1994).

Brown and red algae dominated the samples scrapped off the turtles. These two major taxa of marine macro-algae present lower value than green algae as food for fishes, based on their nutrient and energy contents (Montgomery and Gerking, 1980). However, brown and red algae compose the bulk of food in stomach contents of the western Atlantic *Acanthurus* species (Randall, 1967; Duarte and Acero, 1988; Dias *et al.*, 2001), and we submit that these algae are consumed by those individuals grazing on the turtle. Based on their inspection prior to the nips we suppose the grazers visually select the algae they will pick on the turtle's body. Visual selection seems habitual for some algae grazers, including the green turtle (Montgomery and Gerking, 1980; Sazima and Sazima, 1983; Dias *et al.*, 2001).

So far the Atlantic damselfish *Abudefduf saxatilis* is recorded as an occasional cleaner of reef fishes only (Colin, 1975; Sazima, 1986; Carvalho-Filho, 1999). In this study, however, it was recorded cleaning green turtles, picking at

algae, molting skin, and perhaps small ectoparasites as well. Similarly, the Pacific *A. troschelii*, besides cleaning reef fishes (Hobson, 1968; McCourt and Thomson, 1984), picks off molting skin of submersed marine iguanas, *Amblyrhynchus cristatus* (Hobson, 1969). The also Pacific *A. sexfasciatus* occasionally plucks algal growth from green turtles positioned in mid-water (Booth and Peters, 1972). Species of *Abudefduf* are omnivorous benthic-feeders which may also forage for plankton in the water column (Hobson, 1968; Randall, 1967; Fishelson, 1970; Carvalho-Filho, 1999; Sazima and Sazima, 2001). Nevertheless, Hobson (1971) suggests that substrate-picking predators which also feed on drifting plankton have traits well-suited to perform cleaning. Thus, we predict that cleaning by species of *Abudefduf* on turtles will eventually be found in other areas.

Marine turtles bear ectoparasites such as coronulid and platylepadid barnacles (Bugoni *et al.*, 2001), as well as occasional leeches, whereas reef fishes are infested mostly by copepods and isopods (Grutter, 1994, 1999). We suggest that turtle cleaners do not specialise in this kind of symbiosis, as the habitual and more specialized cleaner species feed mostly if not exclusively on ectoparasitic crustaceans of fishes (Feder, 1966; Losey, 1971; Hobson, 1971; Grutter, 1999). Only particular individuals of the wrasse *Thalassoma duperrey*, an opportunistic and versatile forager, are reported to specialise on parasitic turtle barnacles in Hawaii (Losey *et al.*, 1994). Thus, we suggest that in most instances marine turtles are cleaned by reef fishes which are opportunistic feeders, and/or by those which have a broad diet (even if only occasionally, such as the acanthurids). Indeed, records on reef fishes cleaning reptiles are restricted to substrate-pickers, omnivores, and non-obligate cleaner species (Hobson, 1969; Booth and Peters, 1972; Smith, 1988; Losey *et al.*, 1994; Moll, 1995).

The behaviour of *Chelonia mydas* we recorded at the cleaning stations is undoubtedly an instance of grazing and cleaning symbiosis between reef fishes and marine reptiles (Losey, 1971; Losey *et al.*, 1994). The turtle did not simply passed by or loitered at the cleaning stations, but concentrated on cleaning activities. Additionally, no foraging was ever recorded at the cleaning stations. As the green turtle feeding grounds at the Baía do Sueste do not overlap with the cleaning area, we surmise that the turtles seek for specific sites on the reef to be grazed and/or cleaned. This assumption is strengthened by our observation on a turtle raising to the surface to breathe during a cleaning interaction, and thereafter returning to the same site to resume the cleaning session. Moreover, at cleaning stations the turtles displayed typical soliciting postures, such as hovering in a motionless posture and relaxing the flippers/neck to an extended downward position (see Booth and Peters, 1972; Smith, 1988; Losey *et al.*, 1994 for illustration and descrip-

tion). Additionally, the turtles' forelimb movements to repel an occasional "hasty" cleaner probably are an aversive response to a plausibly painful stimulus due to the removal of a parasite embedded in the skin and/or a sensitive (wounded?) skin portion. These aversive responses are reminiscent of the jerking or shuddering movements performed by fish and turtle clients after an aching bite from their cleaners (Losey, 1971; Losey *et al.*, 1994; Sazima *et al.*, 1999).

Several species of follower fishes are recorded associated with animals as diverse as octopuses, moray eels, rays and other fishes disturbing the substrate during their feeding activity (Karplus, 1978; Ormond, 1980; Diamant and Shpigel, 1985; Strand, 1988). Fish followers are previously unrecorded associated with marine turtles, even though these reptiles are common in the reef environment, particularly during their foraging (e.g., Sazima and Sazima, 1983; Sanches and Bellini, 1999). *Chelonia mydas* grazes primarily on benthic algae and ingests apical portions of larger algae, whereas the smaller ones may be torn away entirely (Sazima and Sazima, 1983). Thus, the feeding behaviour of the green turtle disturbs the substrate, raising drifting particles and uncovering small crustaceans associated to the algae and has the potential to attract fishes which feed on these food types, as is the case of the wrasse *Thalassoma noronhanum* recorded herein. The Noronha wrasse is reported as a benthic invertebrates-picker, plankton-eater, and a cleaner holding mid-water cleaning stations (Francini-Filho *et al.*, 2000; Rocha *et al.*, 2001). However, we noticed that this wrasse is a very versatile forager, that besides picking off plankters and small benthic organisms, acts as follower and part-time cleaner of parrotfishes, grunts and other substrate-disturbing fishes, and often feeds on their faeces (coprophagy, see Sazima *et al.*, 2003). It likely perceives diverse foraging situations and use several kinds of food supplies, acting as a sort of "jack-of-all-trades" forager (see Losey *et al.*, 1994 for comments on *T. duperrey*). Being a cleaner, *T. noronhanum* may perhaps clean the green turtle along with its following behaviour, making shifts between these two roles, a suggestion that remains to be verified. At our study site we recorded such shifts in cleaning and following roles for this wrasse when associated with larger fishes like species of the parrotfish *Sparisoma* and the grunt *Haemulon parra*.

Grazing and substrate-disturbing marine vertebrates other than turtles most probably attract fish followers as well. While foraging on algae, marine iguanas (*Amblyrhynchus cristatus*) are likely candidates to play a nuclear role for opportunistic micro-carnivores as well as planktivores and foragers on particulate matter such as labrids (Hobson, 1991). Marine grazing mammals such as dugongs (*Dugong dugong*) and manatees (*Trichechus man-*

tus) would play a similar nuclear role for fish followers over the sea grass flats and algae beds they forage on.

Taken together, data from the literature and our observations indicate that feeding associations between reef fishes and marine turtles (and other marine vertebrates as well) may be widespread, albeit little studied. Even if widespread, the possibility remains that these are events very localised in space and/or time, or that this is an uncommon behaviour restricted to a few communities and/or populations of reef fishes, which would explain the scarcity of reports about this kind of marine symbiosis (see these views in Losey *et al.*, 1994; Sazima *et al.*, 2003).

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